VALUE ADDITION OF BAKERY AND EXTRUDED PRODUCTS BY INCORPORATION OF WHEAT BRAN, BLACK RICE, MILLETS AND SOYABEAN

SYNOPSIS

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By

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1. **TITLE: Value addition of bakery and extruded products by incorporation of wheat bran, black rice, millets and soyabean**

2. **INTRODUCTION**

Wheat (*Triticum aestivum*) is an important cereal grain used for human consumption as well as feed for livestock. Bran, germ, and endosperm are the main fractions of the wheat grain. Wheat bran is considered as a rich source of several bioactive compounds with potential health promoting characteristics. It is rich in dietary fibers, minerals, and B-group vitamins (Reisinger et al., 2013). The major by-product of the milling industry is bran of which 90 percent is used as livestock and the remaining 10 percent is used in the food processing industry (Hossain et al., 2013). It contains about 53 % dietary fiber (cellulose, xylans, galactans, lignins, as well as fructans). Besides it contains vitamins, minerals, and bioactive components such as alkylresorcinol, flavonoids, ferulic acid, lignans, sterols and carotenoids (Apprich et al., 2013). The aleurone layer of bran is gaining increased research alertness and is presently being studied as a practical constituent in cereal based foods. Minerals present in wheat bran include zinc, iron, magnesium, manganese, and phosphorus. About 80% of phosphorus present in bran of mature grains is present in the form of phytate which is complexed with minerals elements like Zn, Mg, and Fe resulting in decreased bioavailability of above mentioned minerals (Aivaz and Mosharraf, 2013; Coda et al., 2014).

Black rice, the most famous pigmented rice is usually used as an important ingredient in snacks as well as dessert items. High amount of phenolic components, and anthocyanins in

pericarp of black rice, is one of the most potent functional food components (Abdel-Aal et al., 2006; Ryu et al., 1998; Yawadio et al., 2007). The bran layer of black waxy rice comprises a huge level of several bioactive components like anthocyanins, γ-oryzanol, and polyphenolic components. These compounds are helpful in reduction of low-density lipoprotein, improving lipid profile, antioxidative, anti-inflammatory, and anti-diabetic activities (Guo et al., 2007).

Millets are considered as an important food in several under developed countries due to their potential of growing under adverse conditions such as limited rainfall. These have several medical and nutritional benefits (Yang et al., 2012). These are great sources of energy, protein, vitamins, minerals, fatty acids, dietary fibers, and phenolic components. Millet proteins are rich in sulfur containing essential amino acids like cysteine as well as methionine. These are also good sources of antioxidants components, such as glycated flavonoids and phenolic acids (Devi et al., 2011).

Soya bean (*Glycine max* L.) is a leguminous crop cultivated in various countries for its proteins and oil content and used extensively for human and animal foodstuffs (FAO, 2004; Hepperly, 1985). It is an important global crop to have an excellent complex of oil and proteins. It is utilized as protein concentrate, full fat flour, and protein isolate as well as texturized in a wide variety of food products (Adelakun et al., 2013). The protein contents of soya beans provide all amino acids for human health (Liu, 2000).

Therefore, keeping in view the nutritional as well as health benefits of above-discussed food grains, the current investigation is undertaken for value addition of bakery and extruded products by incorporation of these nutritious grains as well as wheat bran after subjecting them to different processing treatments to reduce anti-nutritional components and increasing bioactive potential as well as bioavailability of wheat bran and under-utilized grains.

Objectives:

1. Physico-chemical analysis and functional characterization of raw ingredients i.e. wheat bran, black rice, foxtail millet, finger millet, and soybean.
2. To study the effect of enzymatic treatments on physico-chemical characteristics of the wheat bran and that of fermentation on the nutritional and anti-nutritional components of all ingredients.

3. Optimization of formulations by sensory evaluation for the development of functional foods by incorporation of fermented and enzyme-treated ingredients.
4. Physico-chemical, functional and textural characterization of bakery and extruded products.
5. To evaluate the shelf-life of the developed bakery and extruded products.

Gap in knowledge:

Wheat bran is an excellent source of insoluble fibres that acts as a prebiotic and is highly recommended for bowel health. Besides, it helps to decrease the level of triglycerides and prevent colon cancer. Other ingredients such as black rice, millets (foxtail millet and finger millet) are rich sources of antioxidants, and other bioactive components. Developed functional bakery and extruded products would be quite useful for combating various nutritional as well as lifestyle disorders because of their high functional and nutritional properties besides it will help in proper utilization of wheat bran, a major by-product of the wheat milling industry.

3. EXPECTED NEW KNOWLEDGE

This study will help in the enhancement of nutritional as well as functional characteristics of bakery and extruded products (normally prepared from refined wheat flour or starch) by increasing nutrients such as dietary fibers, antioxidants, and minerals. Treatment of wheat bran with enzymes such as xylanase and cellulase will be effective in increasing the level of soluble sugars and lowering the insoluble fiber, resulting in extensive degradation of the materials present in cell wall. Fermentation will help in augmenting the nutritional properties and bioavailability of nutrients in developed products by reducing the anti-nutritional compounds. This study will help to develop the scope for better utilization as well as of wheat bran and underutilized grain such as black rice and millets.

4. REVIEW OF LITERATURE

Wheat is a major cereal crop grown in many parts of the world as a major food crop. Wheat varieties like *Triticum turgidum* and durum *Triticum aestivum vulgare* are generally used for pasta products (Macrae et al., 1993). The wheat grain consist of three major parts: germ, the endosperm (in which starch grains are filled to supply energy from grain germination); and the aleurone layer which encloses pericarp and endosperm (Pomeranz, 1988). Wheat bran constitutes

approximately 13-19% of the total weight of grain (Hossain et al., 2013). To extract bran from wheat grains, roller mills are used at efficient rate. The wheat grains before milling are first tempered to about 15% moisture content through sprinkling the water and then its transfer into the tempering bin. The time duration in the tempering bin depends upon the hardness of wheat (Brier et al., 2014). The endosperm gets softened during conditioning as the pericarp, and germ of the grain, absorbs water. The conditioning process has the ability to prevent the breaking of bran during its removal from endosperm. The grains after conditioning when passed through the rollers in the roller mill will get cracked, and the endosperm as well as germ is separated from the pericarp (Serna, 2010). These cracked kernels are then divided into germ, endosperm, and bran fractions (Apprich et al., 2013). The conventional milling of the wheat grains depend on the separation of endosperm from embryo and bran layers. In order to form the bran fraction, bran layers, and the embryo along with aleurone cells are removed (Topping, 2007).

High fiber food products have recently gained consumer interest especially because of their association with convenience foods and healthy eating behaviour. Wheat grains being rich in fiber may diminish the risk of lifestyle diseases such as heart diseases, cancer, and diabetes (Fung, 2002; Koh-Banerjee et al., 2004). Wheat bran contains about 33.4% to 63.0%. Based upon their solubility it can be classified as soluble or insoluble dietary fiber. Wheat bran consists of glucan and xylans and its soluble dietary fiber is less than 5% of total dietary fiber (Brouns et al., 2012). The recently developed unit operation such as blasting extrusion process is recently applied to wheat bran to increase its soluble dietary fiber content (Yan et al., 2015). There was an improvement in water and oil absorption capacity and swelling capacity of the soluble fibers by this treatment. Dietary fibres slow the absorption of glucose in the gut and lower the level of cholesterol, low-density lipids as well as enhance intestinal health. Fiber-rich food sources are commonly used for their nutritional, functional as well as technological properties (Patel, 2015). The consumption of wheat bran by people resulted in increasing the satiety value in comparison to their counterparts consuming refined wheat bread (Kristensen et al. (2010).This sign of fullness is attained due to low energy, density and increased viscosity (Ötles and Ozgoz, 2014). It is due to the fermentation of the fiber which leads to water absorption of highly viscous dietary fibers, thereby reducing the gut transit time and increasing the bulk of stools (Almeida et al., 2013).

Black rice production is highest in China with 62% of world production followed by 8.6% in Sri Lanka, 7.2% in Indonesia, 5.1% in India, 4.3% in Philippines, 4.1% in Bangladesh and in the fewer amount in Thailand, Malaysia, and Myanmar (Chaudhary, 2003). It contains excellent amounts of antioxidants and is widely utilized as a source of antioxidants for preparation of functional food products (Yawadio et al, 2007). Being a rich source of polyphenols and anthocyanin content red rice has gained popularity in Japan as a functional food (Itani and Ogawa, 2004). Black rice is demonstrated to have several nutritional benefits in comparison to common rice, as it is rich in proteins, minerals, and vitamins (Suzuki et al., 2004).

The anthocyanin in pigmented rice is able to reduce cholesterol in our body (Lee et al., 2008). Pigmented rice bran can inhibit in vitro allergic reactions as reported by Choi et al. (2007). The black rice anthocyanins include peonidin, peonidin 3-glucoside, and cyanidin 3-glucoside and these have been found to exert an inhibitory effect on cancer cells (Chen et al., 2006). The antioxidant activity and the anthocyanin profile of black rice have been determined through various studies (Ichikawa et al., 2001; Ryu et al., 1998; Yawadio et al., 2007; Choi et al., 2007; Shen et al., 2009; Chotimarkorn et al., 2008; Lai et al., 2009). Black rice has highest amount of total anthocyanin contents (327.60 mg/100 g) among all colored grain (Escribano-Bailon et al., 2004; Lee, 2010, Abdel-Aal et al. 2006). In black rice samples, the level of cyanidin-3-glucoside is found between 22.30 and 140.30 mg 100 g/l (Frank et al. (2012). The subspecies japonica and indica have total anthocyanin content ranging from 121.30 to 155.90 mg/100 g and 32.40 to 50.30 mg/100 g, respectively. The total contents of anthocyanin in the black rice are in the range of 109.50 and 256.60 mg/100 g (Sompong et al. 2011).

Pigmented rice varieties have been proved to lower the risk of atherosclerosis as proved in several *in vivo* studies on rats taken as animal models (Xia et al., 2006). Several studies have demonstrated that the anthocyanins can prove to be an alternative for synthetic dyes due to their solubility and attractive colors which makes them suitable to be used into foods to provide positive health benefits to humans (Bridle and Timberlake, 1997; Nontasan et al., 2012).

Fermentation is considered an excellent processing technique for legumes and cereals. It helps to increases the level of nutrients, improves digestibility as well as bioavailability and changes some physical properties of legumes and cereals (Hesseltine, 1965; WHO, 1998). It has been found to decline the levels of antinutrients, improves nutrient density, and imparts

antimicrobial characteristics to fermented grains (Tomkins et al., 1987; Nnam, 1999; Mensah et al., 1990). FAO/WHO has stated that probiotics are “live microorganisms which when administered in adequate amounts confer a health benefit on the host”. Millets being rich sources of dietary fibers act as potential prebiotics and can help to improve the functionalities of probiotics with considerable health benefits. To enhance the body’s resistance against pathogenic microorganisms, most of the probiotic foods produce fatty acids, vitamins, and various other vital components (FAO, 2002).

Millets are the major food sources for the people living in hot and humid climate. Due to their high nutritional profile, millets are widely used in numerous traditional foods as well as beverages such as bread, porridges as well as snack foods (Chandrasekara and Shahidi, 2011). It has been found that millets have excellent benefits like prevention of cancer and tumor incidences, lowering of blood pressure, and risk of heart diseases (Truswell, 2002; Gupta et al., 2012). To improve the nutritional and sensory properties, millets before consumption are prepared by conventional techniques such as fermentation, decorticating, flaking, and grinding. The nutritional components in the whole grain matrix demonstrates to have positive health benefits (Slavin, 2003; Fardet, 2010). The demand for healthier foods has recently gained consumer interest which leads to the incorporation of traditional and unconventional foodstuff in food production.

Among all bran-incorporated food products, cereal and bakery foodstuffs are the topmost ingredients with about 60% market value (Pr€uckler et al., 2014). Over the years, wheat bran has gained increased attention in bakery and fried cereal foods. Various studies conducted to know the effect of wheat bran on sensory characteristic of both cereal as well as non-cereal foods and it depends on the types of food (Sozer et al., 2014), the particle size of bran (Kim et al., 2013), pre-treatment of bran (Reyes Pérez et al., 2013) and different types of cooking methods used. However, the incorporation of wheat bran at higher concentrations has been reported to deteriorate the sensory quality of end products. The addition of 10 to 30 percent of wheat bran has improved the nutritional content in cakes but the incorporation of bran at a level above 10% has adversely affected the mouthfeel, taste, appearance, and overall acceptability scores of the cakes (Lebesi and Tzia (2011)

5. TECHNICAL PROGRAMME OF WORK

Experiments planned in accordance with the objectives are described under the following subheads

Objective 1

Physicochemical analysis, anti-nutritional components and functional characteristics of raw ingredients i.e. wheat bran, black rice, foxtail millet, finger millet, and soybean

Location: Laboratories of the Department of Food Technology

i. **Methodology:** As per standard protocols.

a) Observations to be recorded: Physico-chemical parameters

i. Thousand-grain weight
ii. Bulk Density
iii. Tap Density
iv. Dimensional properties (length, breadth, and thickness)
v. Water absorption capacity (WAC)
vi. Water solubility index (WSI)
vii. Oil absorption capacity (OAC)

b) Nutritional, Anti-nutritional and Functional Characteristics

i. Proximate composition
ii. Mineral contents (Ca, Fe, Zn, Mn, Cu)
iii. Anti-nutritional factors (Phytic acid, tannins, Trypsin inhibitor activity)
iv. Total Phenolic contents
v. Flavonoid contents
vi. Antioxidant activity

c) Optical properties

Color values (L, a, and b values)

Objective 2

To study the effect of enzymatic-treatments on physico-chemical properties of the wheat bran and that of fermentation on nutritional and anti-nutritional components of all ingredients

Location: Laboratories of the Department of Food Technology

Methodology: As per standard protocols.

Observations to be recorded: Effect of enzymatic treatment (cellulase and xylanase) on physicochemical properties of wheat bran and that of fermentation on nutritional, anti-nutritional components and functional characteristics of all ingredients by subjecting them to the following treatments

Fermentation

T1- Natural fermentation of raw ingredients without any starter culture

T2- Fermentation with active dry yeast (saccharomyces cerevisiae L.)

T3- Fermentation with Lactic acid bacteria (LAB)

T4- Fermentation with active dry yeast and LAB (combined affect)

Enzymatic treatment of wheat bran

T1- enzymatic treatment with enzyme cellulose

T2- enzymatic treatment with enzyme xylanase

*Treatments will be screened based on their effectiveness in increasing the nutritional value and decreasing anti-nutritional components as well as textural characteristics of wheat bran and the best treatment will be utilized for the development of food products.

Observations to be recorded:

Nutritional, anti-nutritional, and functional components as mentioned in Objective 1 (b)

Objective 3

Optimization of formulations by sensory evaluation for the development of functional foods by incorporation of fermented and enzyme-treated ingredients

Location: Laboratories of the Department of Food Technology

Methodology: As per standard protocols

Grains treated with best processing treatments (screened on the basis of increasing nutritive value, and decreasing the anti-nutritional components) will be utilized for the preparation of functional food products.

The judicious combinations of processed grains will be utilized for the preparation of different composite flour formulations to be utilized for the development of functional food products (Cookies, pasta, puff balls) by taking whole wheat flour products as control

The best formulation for each product will be screened based on organoleptic evaluation of different formulations.

Observations to be recorded:

The organoleptic evaluation will be done using the 9-point hedonic scale for color, flavor, texture, taste, and overall acceptability

Objective 4

Physico-chemical, functional and textural characterization of bakery and extruded products

Location: Laboratories of the Department of Food Technology.

Methodology: As per standard protocols.

Observations to be recorded:

a) **Nutritional. Anti-nutritional and functional components:** As mentioned in objective 1 (b)

b) Anti-oxidant activity

c) Reducing capacity

d) Bioavailability of micronutrients (Zn and Fe)

e) Textural characteristics: (Texture profile by texture analyzer)

Objective 5

To evaluate the shelf-life of the developed functional food products

Location: Quality control labs of the Department of Food Technology.

Methodology: As per standard protocols.

Physico-chemical parameters, organoleptic, and microbiological evaluation of products packed in different packaging materials (HDPE and Laminates) will be assessed at different time intervals using standard protocols.

Observations to be recorded:

i. Nutritional, anti-nutritional, and functional components: As mentioned in objective 1 (b)

ii. Organoleptic evaluation by the 9-point hedonic scale

iii. Total plate count

Statistical Analysis: By SPSS statistical package using one way/two way ANOVA and test of significance.

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